Electronic Supplementary Material (ESI) for Sustainable Energy & Fuels.

Supplementary information for

Facile Synthesis and Characterization of γ-Al_2O_3 Loaded on Reduced Graphene Oxide for Electrochemical Reduction of CO_2

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Content of Supporting Information

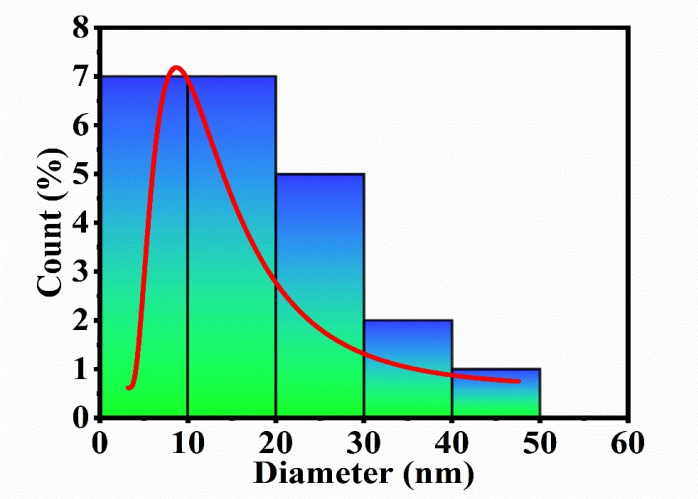

Figure S1. Particle size distribution curve for Al_2O_3 particles on rGO. The curve demonstrates that the average particle size of Al_2O_3 on rGO is in the range of 8 to 12 nm.

Concentrations

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QTEGRA

Instrument Name	Serial Number
iCAP RQ	Undefined

LabBook	LabBook Path
REQ NO 2385 2388 2401.imexp	_Application Data\Workspace\LabBooks\2022\09 September 2022

Analysis index: 29
Analysis label: A 2
Analysis started at: 08/09/22 02:12:25 PM
User name: ADMINTH-HKUUMBR\Administrator

Category	27Al (KED)
Concentration average	0.387 ppm
Concentration per Run 1	0.398 ppm
Concentration per Run 2	0.376 ppm
Concentration per Run 3	0.388 ppm
Concentration RSD	2.8 %

Figure S2. The amount of Al in Al_2O_3-rGO nanocomposite materials as determined by ICP-MS. The result shows that the amount of Al on rGO surface is 2.8 wt.%.

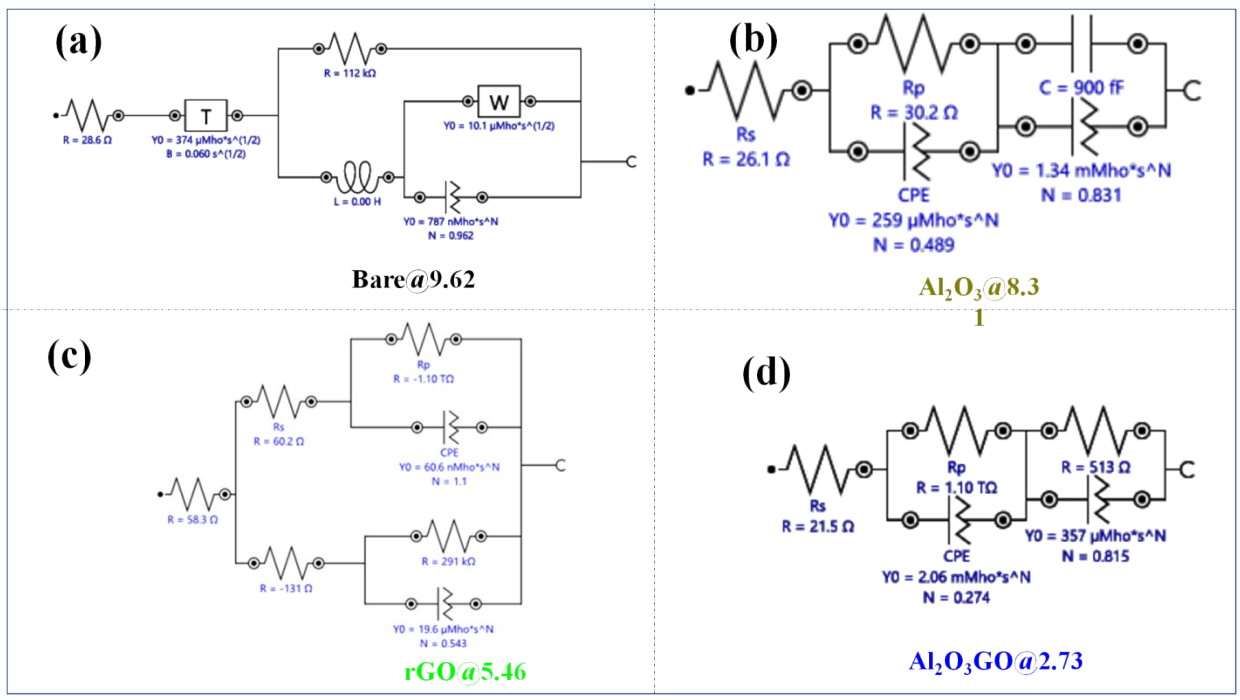

Figure S3. The equivalence circuit model corresponding to the impedance spectra and the values of resistances at electrified interfaces during CO_2 reduction reactions over: (a) bare GC electrode, (b) Al_2O_3 NPs-modified GC electrode, (c) rGO-modified GC electrode and (d) Al_2O_3-rGO hybrid nanomaterial-modified GC electrode. The results are obtained using their EIS plots.

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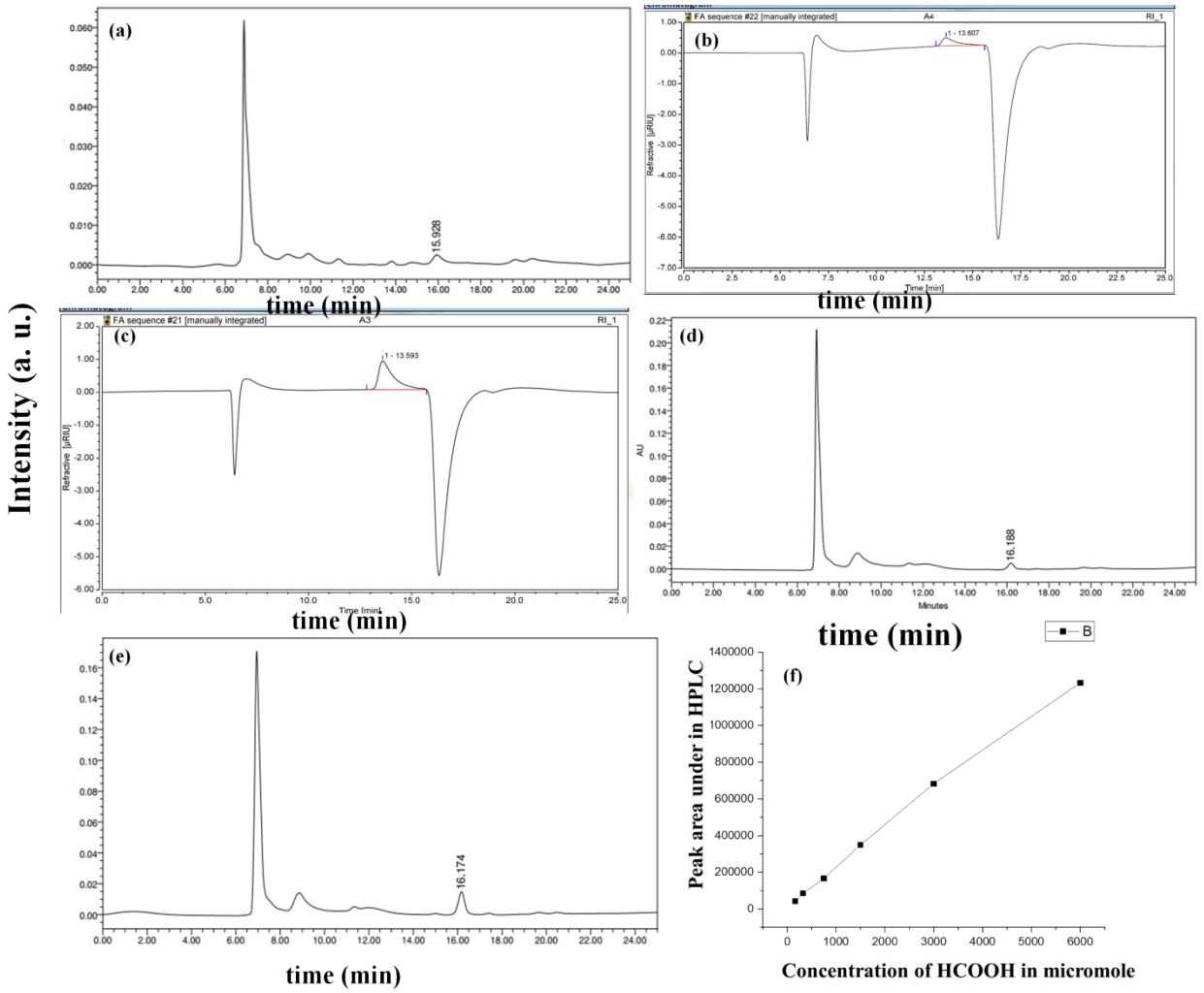

Figure S4. HPLC analysis data of the bulk electrolysis products indicating the formation of formate. The results show the products formed from the reactions that are run (a) at a potential of -0.434V vs. RHE, showing 0.01 mM formate; (b) at -0.54 V vs. RHE, showing 0.025 mM; (c) at -0.64 V vs RHE, showing 0.031mM; (d) -0.734 V vs. RHE, showing 0.040 mM formate; and (e) at -0.934 V vs. RHE, showing 1.269 mM formate. (f) The standard calibration curve obtained with known amounts of formate is included for comparison with experimental data. In the figures, a.u represents arbitrary unit.

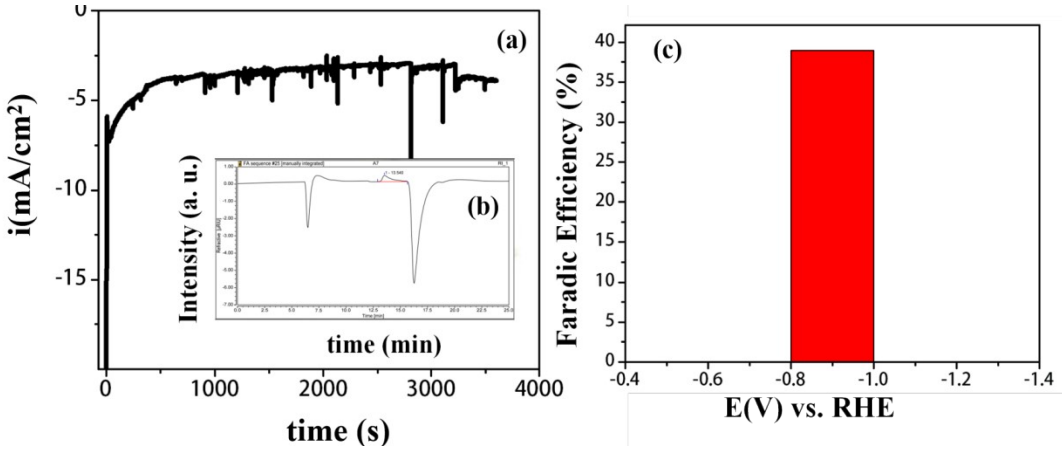

Figure S5. Bulk electrolysis (a) (i-t) curve for the CO_2RR over rGO as electrocatalyst in CO_2-saturated solution for 3600 s at -0.934 V vs RHE. (b) Confirmation of the formation of formate product using HPLC data.(c) The value of FE is obtained to be 39 % for CO_2RR rGO electrocatalyst in 3600 s at -0.934 V vs RHE,

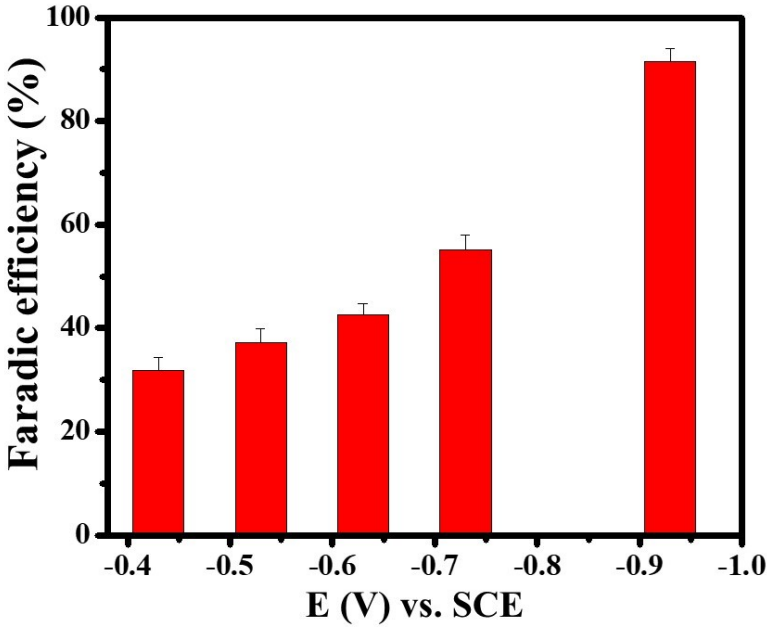

Figure. S6. Faradaic Efficiency (FE) values along with error bars for the formation of formate (red rows) as a major product during electrocatalysis of CO_2 reduction reaction over Al_2O_3-rGO hybrid electrocatalyst.

Table S1. Comparison of the activity of the catalyst reported in the present work with notable electrocatalysts reported in the literature. The electrocatalytic conditions, electrolyte, and potential observed for reduction, Faradic efficiency, references, etc. are also listed.

Sr. No	Electrocatalytic System	Electrolyte	Cathodic Potential	Faradaic Efficiency (FE %)	Ref.
1.	Carbon-supported Bi nanoparticles	0.5 M $KHCO_3$	-1.5 V vs. AgCl/Ag	93 %	1
2.	Carbon black supported SnO_2	1.0 M KOH	-1.43 V vs. RHE	80%	2
3.	Sn-In bimetallic electrodes.	0.1 M $KHCO_3$	-1.6 V vs. Ag/AgCl,	88%	3
4.	Copper (I) oxide nanoparticles	0.5 M $KHCO_3$	-0.8 V vs RHE	66%	4
5.	Sn-based gas diffusion electrode prepared by Sn on Nafion-bonded carbon black	0.5 M $KHCO_3$	-0.5 V vs. RHE	73.01%	5
6.	SnO_2 supported by γ-Al_2O_3	0.1 M $KHCO_3$	-0.95 V vs. RHE	65 %	6
7.	γ-Al_2O_3 decorated reduced graphene oxide (rGO)	0.5 M $KHCO_3$	-0.934 V vs. RHE	91.20 %	Present Work

References

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